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THE GROWING AND HANDLING OF HEAD LETTUCE IN CALIFORNIA

H. A. JONES AND E. L. GARTHWAITE

FOREWORD

Within the past few years there has been a very great increase in the production and consumption of lettuce in the United States. This increase in consumption has followed closely the introduction of the variety of head lettuce known as New York, which in the United States is grown only in the western irrigated regions. The greatest increase in production has been in California and other Pacific Coast and Rocky Mountain states, where the crop is grown almost entirely under irrigation. Fig. 1 shows the great increase in carlot shipments of lettuce in the United States and in California since 1917. Most of the lettuce produced near the large cities and consuming centers in New Jersey, New York, and other states is hauled to market by truck and therefore does not appear in these carlot totals. In 1923, over 40 per cent of all carlot movements in the United States originated in California and in 1924 nearly 60 per cent.

PRODUCTION AREAS OF THE UNITED STATES

The New York variety is produced in the irrigated regions of the West, including Arizona, California, Colorado, Idaho, Oregon, Utah, and Washington. Big Boston is grown in the Middle West, East and South, particularly in Florida, Michigan, New Jersey, North Carolina, South Carolina, and Texas. Attempts have been made to grow the variety New York in the East, but the heads do not become so firm nor the quality so good as when raised under Western conditions.

Shipping Seasons of Different States.—Fig. 2 gives the approximate lettuce-shipping seasons for the important lettuce-producing states and districts. The shipping season of each locality varies slightly from year to year with seasonal conditions.

Carlot Movements from Different States.—As California ships lettuce throughout the year, it must compete to a certain extent with lettuce shipped by all other states. Table 1 shows the carlot movements for the entire United States by months for the years 1918 to 1924, inclusive.

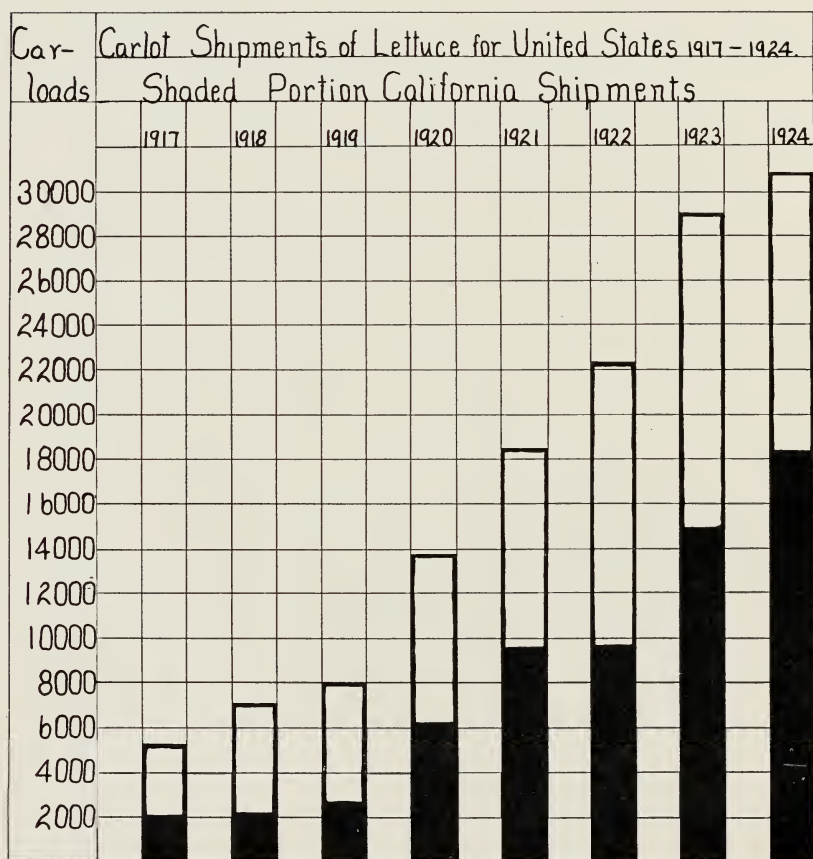


Fig. 1.—Carlot shipments of lettuce for United States 1917-1924.
Shaded portion, California shipments.

TABLE I

CARLOT SHIPMENTS OF LETTUCE FOR THE UNITED STATES BY MONTHS, 1918-1924

Years	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1918.....	957	1124	1167	725	499	92	382	560	383	123	319	628	6959
1919.....	767	717	829	1090	831	181	395	695	653	358	565	937	8018
1920.....	2023	1621	1353	1063	1172	365	980	934	832	596	1388	1491	13818
1921.....	2356	1984	2219	1974	1067	670	1399	1140	1302	1253	1481	1771	18616
1922.....	2245	1919	2584	3167	1859	801	1536	1787	1303	1503	1453	2083	22240
1923.....	3119	2736	4099	2520	2015	1310	2232	2493	1839	2048	2285	2789	29485
1924*.....	3807	3626	2789	2885	3087	1261	1715	2053	1821	2145	2762	2840	30791

Bureau of Agricultural Economics.

* Subject to revision.

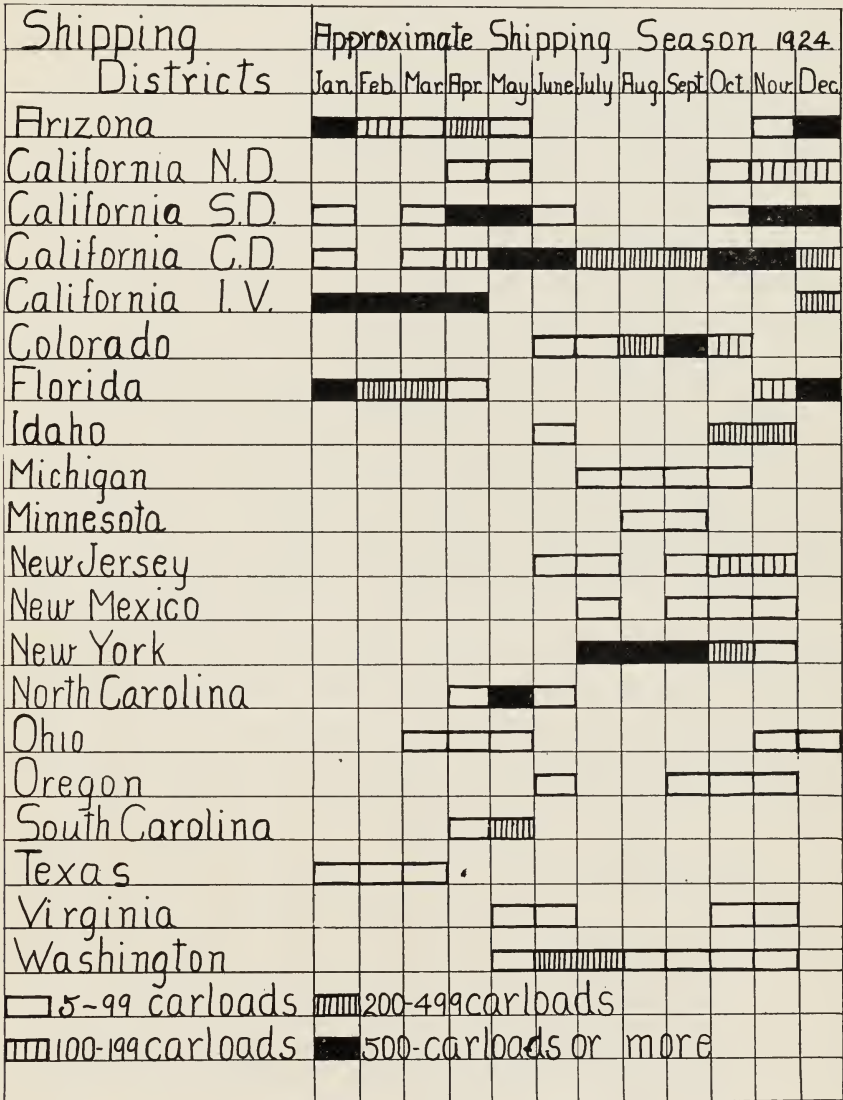


Fig. 2.—Shipping districts. Approximate shipping season, 1924.

PRODUCTION AREAS IN CALIFORNIA

The main lettuce-producing areas in California until recently have been in the Imperial Valley and in the vicinity of Los Angeles. Within the past two or three years, however, many new lettuce districts have sprung up along the coast and in the interior valleys. Lettuce growing in many of these new districts is still in the experimental stage. It will take some time to determine definitely what regions are best adapted to the production of head lettuce of high quality. This circular is intended to give growers in the newer districts, many of whom are producing lettuce for the first time, information regarding some of the best practices in the older-producing areas. The main need of the industry at present is the production of lettuce of high quality, which can be accomplished only by a wise selection of location and the adoption of the best cultural practices. Poor lettuce is never profitable and too much of that is already being produced.

Shipping Seasons for California Lettuce.—The principal shipping season for California lettuce is during the late fall, winter, and early spring. Most of the lettuce shipped from the Imperial Valley moves during late December, January, February, March and early April. The Los Angeles district ships the greater portion of its crop during November, December, April, and May, before and after the movement of lettuce from the Imperial Valley. The shipping period for the San Joaquin Valley practically coincides with that of the San Fernando Valley. The development of new districts along the coast in Ventura, Santa Barbara, Santa Cruz, Monterey, and other counties has made possible the shipment of lettuce throughout the summer. Many of these districts are temporary because they are not adapted to growing this crop during the summer. Nevertheless, more and more lettuce is being shipped during the summer months as new districts are found that are suited to its production. Table 2 shows the carlot shipments of lettuce for California by months for the years 1918 to 1924.

TABLE 2
CARLOT SHIPMENTS OF LETTUCE FOR CALIFORNIA BY MONTHS 1918-1924

Years	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1918.....	263	471	685	162	194	43	2	8	14	12	50	147	2051
1919.....	132	295	551	555	491	69	25	11	17	96	249	240	2731
1920.....	757	1025	985	653	870	226	74	69	52	210	851	578	6350
1921.....	1458	1402	1357	1310	897	272	202	153	139	395	987	1174	9746
1922.....	1312	902	1456	2014	1294	391	184	104	91	220	676	1100	9744
1923.....	2953	2043	3227	1659	1410	430	395	507	296	450	1241	1502	15113
1924*.....	2256	3185	2461	2291	1952	839	380	203	279	1080	2015	1461	18404

Distribution of California Lettuce.—California lettuce is widely distributed throughout the United States and Canada at most seasons of the year. California summer lettuce, however, is not always so widely distributed as the winter crop. The tendency is to place summer lettuce on markets nearby, especially if the carrying quality of the product is uncertain. Most of the lettuce is shipped in carlots, but there is a considerable quantity moved in mixed cars to centers of small consumption.

CLIMATIC AND SOIL REQUIREMENTS

Temperature Requirements.—Lettuce of high quality can be produced only where the temperature of the soil and air is moderately cool and uniform. This requirement, i.e., a cool, uniform temperature, must be kept in mind, especially by those who are attempting to grow lettuce during the summer months. Fluctuating high and low temperatures are not conducive to good growth. High temperatures favor the production of seed rather than foliage, cause a bitter taste in the product, produce loose heads, and accelerate the development of lettuce diseases. During the early stages of development, lettuce will tolerate a considerable amount of frost, but if severely frosted when mature or nearly mature, it is more subject to disease and does not stand shipment. Generally, frosted lettuce needs close trimming, and is therefore not attractive. The maturing plants make very little growth during continued frosty weather, and although they become solid, they remain small, their leaf tips are injured, and they bring a comparatively low price.

Moisture Requirements.—Lettuce must have an adequate supply of moisture throughout the growing season. However, an excessive amount of water in the soil is not desirable.

Soil Requirements.—Lettuce is grown successfully on a wide range of soil types from clay loams to sandy loams and muck, but it attains its highest quality on fertile loam soils which contain much organic matter. Where the fall crop is subject to high temperatures during the early part of the growing season, or where it matures during hot weather, the heavier types of soil should be used, as they retain moisture better and are somewhat cooler. The lighter soils should be used to produce the crop that grows and matures during the cool season of the year. Heavy clay soils, though difficult to work, will yield excellent crops. All lettuce land should be well drained and properly leveled for irrigation. Land which has been in alfalfa for several years, usually produces large crops of high quality.

SOIL IMPROVEMENT

If the land is not sufficiently fertile to produce a fairly rapid growth and a large firm head, it should be improved by applying manure or commercial fertilizers or both, and by growing cover crops. The plant food elements should be present in available form and in sufficient amount to give a continuous growth. While phosphorus, potash, and other plant food elements are necessary, the one usually needed most is nitrogen.



Fig. 3.—Lettuce growing between English walnuts. Los Angeles County.

Crop Rotation.—While as many as five or six crops of good lettuce have been grown consecutively, it is seldom that more than two are profitable without some sort of rotation. Various lettuce diseases accumulate in the soil and infect succeeding crops. In the Imperial Valley, alfalfa has been used commonly in the rotation. Lettuce is often planted directly on alfalfa sod, but more often after an intervening crop of cantaloupes. The second year, cantaloupes or some field crop like cotton or grain is followed by another lettuce crop. The third year after growing cantaloupes or some field crop, the land is again resown to alfalfa. A deep-rooted legume crop if followed by a series of shallow rooted non-legume crops makes a good rotation. Cantaloupes and grain crops draw heavily on the potash

and phosphate supply of the soil, while lettuce requires a good supply of nitrate for its best development.

In the San Fernando Valley, lettuce is grown almost entirely as an intercrop among deciduous fruit and English walnut trees, as shown in Fig. 3. It is planted in the fall when the foliage is off the trees, so extreme shading does not occur. Spring lettuce is also grown after fall crops of cauliflower, tomatoes, celery, or fall lettuce. Fall lettuce often follows spring potatoes. In Los Angeles county, land is high-priced, and it is necessary to keep it occupied with crops that are highly profitable.

Manuring.—Probably the best fertilizer for lettuce is barnyard manure. It is usually best to compost the manure before applying to the land, especially if the field is to be planted with lettuce immediately. In composted manure, more of the plant food elements are in an available form; there is no coarse material to interfere with planting and cultivation; many of the noxious weed seeds have been destroyed; and there is no heating of the soil. In composting, however, an effort should be made to prevent leaching of the soluble salts and the loss of ammonia by heating. If fresh or unrotted manure is used, it should be applied and plowed or disked under in time to allow it to decompose and become incorporated with the soil. Decomposition of the manure after it has been plowed under may be accelerated by flooding the land. In tests carried on in the Imperial Valley, an application of 10 tons an acre of barnyard manure increased the total yield 54 per cent, and caused the lettuce to mature two to four weeks earlier, and produce larger heads of better quality than the adjoining unmanured plots. Excessive applications, however, especially in warm weather, will often cause loose heads. Not only does barnyard manure supply plant food, but its organic matter lightens the heavier soils, which improves aeration and water penetration, and increases the water holding capacity of light soils, which cuts down irrigation costs by decreasing the number of irrigations needed.

Green Manure Crops.—Where manure can not be obtained in sufficient amount to supply the needed organic matter and plant food, green manure crops alone or green manure crops in conjunction with commercial fertilizers may be used. A cover crop or green manure crop, preferably a legume, should be chosen that is adapted to the local climatic conditions and that produces a good tonnage of vegetable matter. It is better to grow cover crops rather than to let the fields lie idle during a part of the year. Such crops keep down the weeds and,

besides adding to the total organic content, help conserve the soluble mineral elements of the soil, especially in regions of heavy winter rainfall. They prevent erosion, help aerate the subsoil, and increase the favorable bacterial flora of the soil. By the addition of organic matter, they improve the texture and increase the moisture-holding capacity of the sandy soils. Brabham cowpeas and Laredo soybeans have been shown to be the best summer green manure crops for Imperial Valley conditions, not only because they give a large tonnage, but because they are resistant to nematode attack. It is important to give a thorough disking before plowing under the green manure crops.



Fig. 4.—Brabham cowpeas in Imperial Valley. This crop will yield 24 tons of green tops to the acre, outyielding other varieties of summer legumes. Brabham and Iron cowpeas and Laredo soybeans are resistant to the attacks of nematodes.

If the soil is dry, irrigation after plowing will hasten decomposition. This must be fairly complete before the next crop is planted, otherwise injurious results are likely to follow.

Commercial Fertilizer.—Many of the growers are planting green manure crops and supplementing them with commercial fertilizers to keep the soil in a state of high productivity. The three constituents supplied in a complete fertilizer are nitrogen, phosphorous, and potash. Any one or all of these may be supplied in the organic or inorganic form. In the inorganic form, the elements are immediately available to the plant, while in the organic form, the complex compounds must undergo decomposition into more simple forms before they can be absorbed by the plant. This decomposition or change is effected by different bacterial groups in the soil. When the temperature of the soil is low, these bacteria function slowly or not at all, so it is better, during the cooler seasons at least, to apply the fertilizers in the inorganic form.

It is impossible to specify a single kind or uniform amount of fertilizer for the entire state or for any large district within the state. It is best for each grower to make a number of tests on his own farm to determine the kind of fertilizers to use, and the most profitable amount to apply. In general, it is the lack of nitrogen that usually limits the growth of the lettuce plant. Nitrogen can be applied in the inorganic form as nitrate of soda or sulphate of ammonia. Tankage, fish meal, cotton seed meal, dried blood, and other compounds can be used to supply the organic form. A complete fertilizer is often



Fig. 5.—Fertilizer drill used to apply fertilizer to the sides of the lettuce beds. A plumber's Y of two-inch pipe is fastened to the frame underneath the fertilizer hopper of an ordinary combination corn planter and fertilizer drill. This facilitates a uniform distribution of the fertilizer along the sides of the bed.

broadcasted or drilled in after plowing and before the beds are made, but may be drilled in the center or in the sides of the bed before planting the seed. Ammonium sulphate or nitrate of soda may be applied as a side dressing after the plants have been thinned and until about a month before harvesting. Usually 75 to 100 pounds or more are used to the acre in this way by drilling it in along the side of the bed, as shown in Fig. 5, or spreading it in the furrows before irrigation. It is usually best not to apply large amounts of nitrogen after the heads have started to form, especially in warm weather as the heads are liable to burst.

PREPARATION OF LAND PREVIOUS TO PLANTING

Leveling.—It is essential in the growing of lettuce under irrigation to have the land level and the beds of a uniform height so that water can be applied without flooding certain areas and leaving others high and dry. The fall should be gradual, so that the entire bed can be well moistened. If leveling is necessary it should be done well in advance of the planting season. If much dirt has to be moved, it is best to make a test irrigation to settle the soil and reveal the depressions and elevations. The necessary retouching can be done after the



Fig. 6.—After applying, a shovel cultivator is used to cover the fertilizer and open the furrow for irrigation water.

soil has become sufficiently dry. It is a frequent practice after leveling to improve the places where the top soil has been removed by means of manure or a commercial fertilizer and a cover crop. By following this practice, a more uniform crop of lettuce is produced.

Preparatory Tillage.—In general, the soil should be plowed and then disked and harrowed to a fine, mellow condition before the seed beds are made. It is difficult to make good beds or do good seeding on a cloddy soil. When seeding is done during very hot weather, however, aeration is facilitated and better stands are obtained if the soil is left a little crumbly. When alfalfa land is broken up preparatory to putting in lettuce, it is given a deep plowing several months in advance and allowed to remain in this rough condition until about a month before planting. A second plowing is then given, followed

by a quick irrigation. As soon as the ground is dry, it is disked and then leveled with a float, as shown in figure 7, after which the beds are made.

The soil should be thoroughly worked before planting. A common sequence of operations for land that has just grown a cultivated crop is plowing about eight inches deep, a double disking, and floating, then replowing, disking, cross disking, floating, and bedding.



Fig. 7.—Floating or smoothing the ground after disking just before making the beds. This operation lowers the high places and fills in the depressions.

Making the Beds.—Practically all of the lettuce in the irrigated regions of the West is planted on raised beds. In California, the general custom is to grow two rows on a bed with furrows between the beds to carry the irrigation water. In some Western states the

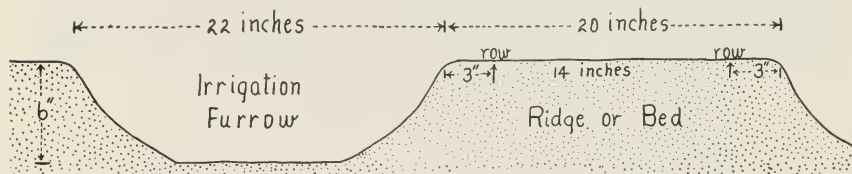


Fig 8.—General type of bed and furrow used in the growing of lettuce in California. Dimensions vary according to local conditions.

planting of single rows on raised beds is still practiced. Usually a larger yield is produced where two rows are grown on a bed. The one row bed, however, requires somewhat less expense for cultivation. The bed and furrow system, as shown in figure 8, facilitates irrigation and drainage and gives good aeration about the plants.

The width of bed, distance between beds, and depth of furrow vary in different regions, according to the climatic conditions and type of soil. The beds vary from 18 to 20 inches or more in width, and the furrows from 18 to 22 inches or more. It is seldom that the beds are less than three feet from center to center, and usually they are further apart than this. They should be made so that they will be 4 to 10 inches high after smoothing. If the furrows are not made suffi-



Fig. 9.—Throwing up lettuce ridges with single and double listers.

ciently deep, there is danger of flooding the beds. Inexperienced growers have a tendency to make them too shallow. In regions where strong dessicating winds are prevalent, and on light, sandy soils, low beds are to be preferred, as they expose less surface and retain the moisture better.

A number of different implements have been devised to make the lettuce beds or ridges. A disk, turning plow, a single or double lister, as shown in figure 9, or a two row cultivator equipped with large shovels may be used. Many growers throw them up with a plow or lister and level them with a drag or sled. In Imperial Valley, the



Fig. 10.—Furrows have been made and the beds are ready for shaping and planting.

general practice is to make the furrows with a single lister pulled by two horses, or with a double or triple lister behind a tractor. The beds are then shaped with a sled just before the seed is planted. Fig. 11).



Fig. 11.—One method of making and leveling the beds. Disks attached to the runners in front help to make the furrows.

VARIETY TO PLANT

Practically the only lettuce grown at the present time in California for shipment is the New York, and it is the variety upon which the reputation of Californian lettuce has been built. It is also known as Los Angeles, Los Angeles Market, Wonderful, New York Special, and Mountain Iceberg. According to Morse,* this variety is known in Europe as Chou de Naples or Neapolitan Cabbage. The shippers and buyers refer to this variety as Iceberg. The variety which the seedsmen

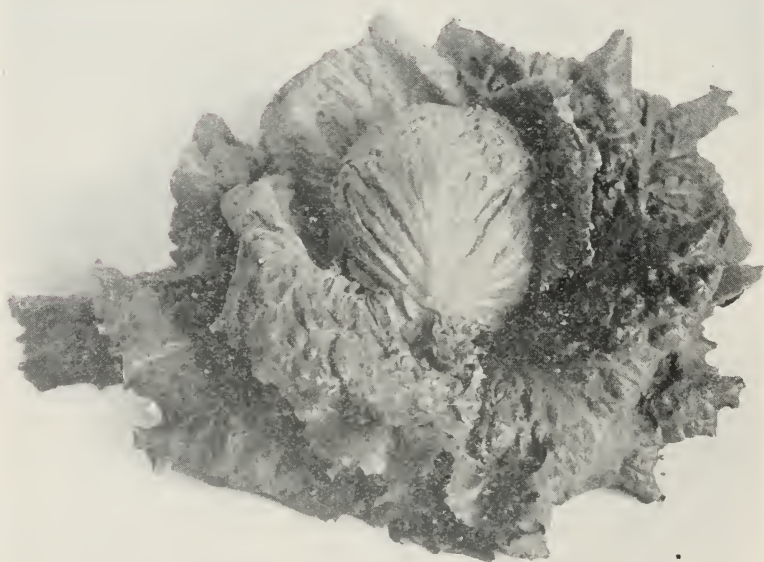


Fig. 12.—A specimen of New York lettuce, practically the only variety shipped from California.

know as Iceberg has the edges of the leaves tinged reddish brown, while the New York is entirely free from brown, and forms a somewhat firmer head. The true New York variety, as shown in figure 12, is a crisp, large heading, dark green variety with the mature head of a slightly flattened globe shape. Some strains of New York have slightly elongated heads. These are not so easy to pack in the crate as those that are slightly flattened, and are not so well received on the market. However, some of the best strains of lettuce under certain climatic conditions fail to mature heads of the desired shape.

* Morse, Lester L. "Field Notes on Lettuce." C. C. Morse Seed Co., San Francisco, Cal., pp. 76, 1923.

Practically all of the lettuce seed of the New York variety is produced in California. Freshly harvested or new seed does not germinate so well as that which has been stored, so it is the general custom among seedsmen to store lettuce seed for a year before selling it to the grower.

SOWING THE SEED

Various tools have been devised for sowing. Usually the two rows on top of a bed are sown in a single operation by implements similar to those shown in figures 13, 14 and 15, but a gang of four planters

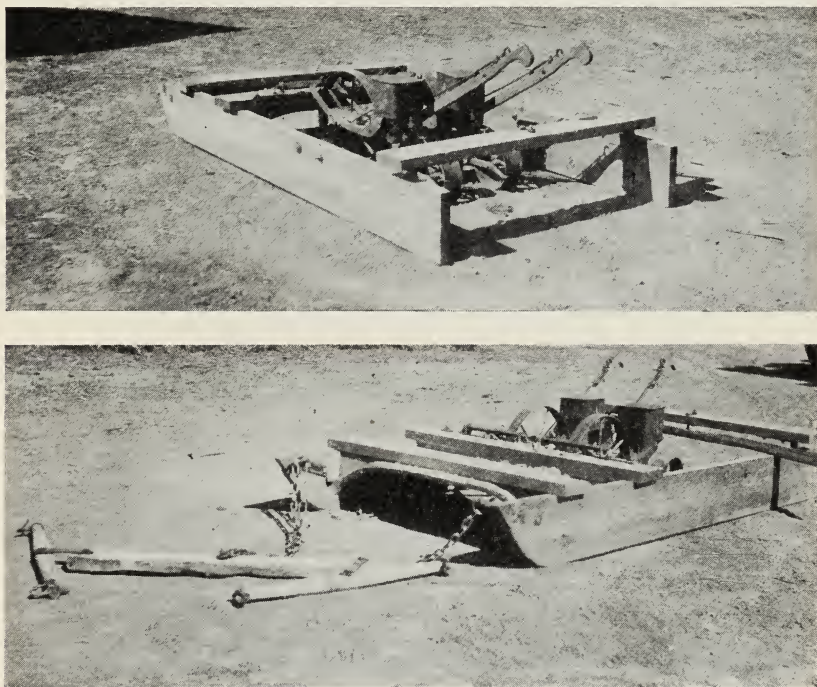


Fig. 13.—This tool shapes the beds and plants two rows of seed in one operation. The runners are sufficiently long to hold the tool steady and the seeders are flexible enough to conform to the slight irregularities of the bed. Imperial Valley.

can be used if the two beds have been made at the same time, as shown in figure 16. If the planting is done as a separate operation after the beds have been completed, a two row planter that straddles the furrow is generally used, similar to the one shown in figure 17. Hand pushed drills are sometimes used. Most growers attach two planters to the sled that shapes the bed. This system saves time, and further-

more, the two rows of lettuce on a bed are exactly the same distance apart throughout their length. This facilitates work with "stirrup" or other wheel hoes and cultivators on top of the beds. It also makes easy the cultivation of the furrows and sides of the bed, because the plants are all at the same distance from the edge.



Fig. 14.—This sled is used to shape the beds and to plant two rows on the same bed in one operation. The lever on top enables the driver to lift the planters when turning at the end of the rows. The lettuce rows on the bed are always the same distance apart, making possible the use of "stirrup" weeders. Large cultivators can be used that work the top and sides of the bed in one operation.



Fig. 15.—This tool makes the furrows, shapes the beds and plants the seed in one operation.

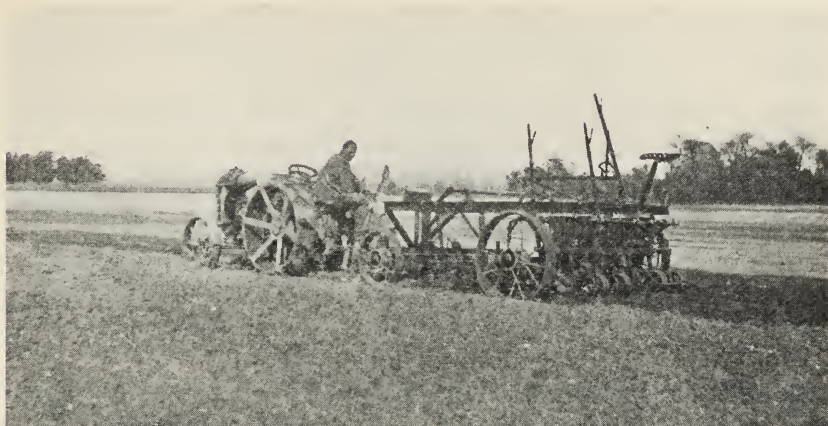


Fig. 16.—A machine designed to complete two beds and plant four rows of lettuce in one operation.

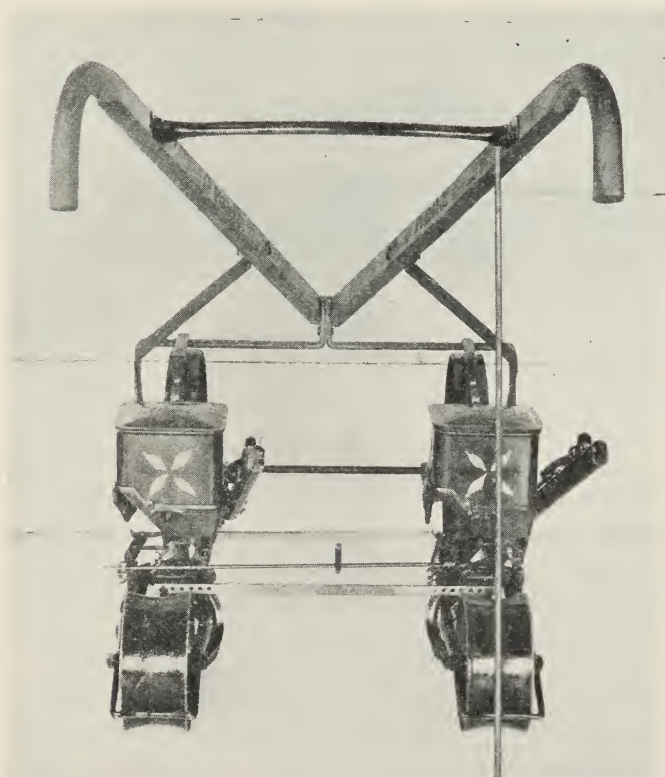


Fig. 17.—This type of two-row planter is sometimes used to straddle the furrow.

Lettuce seed is very small and should be sown as shallow as possible, but it must be covered with sufficient soil to insure germination. It will not germinate at high temperatures unless the soil is well aerated. This aeration is accomplished by leaving the seed bed slightly coarser than is the practice during the cool season of the year.

Very thick seeding is objectionable. The labor cost of thinning the thick stand of plants is expensive; and there is the additional waste of high priced seed. From one to one and one-half pounds of seed to the acre is sufficient if all the seed is viable and the soil temperature and moisture conditions are favorable.

The distance between rows should not be less than ten inches. Some growers space the rows from 15 to 17 inches to give room for the development of large heads. Where the rows are too close together on top of the bed, cultivation is more difficult and expensive, various diseases are likely to develop, and the mature heads are usually smaller. In general, the plants grow better when they are not too near the edge of the bed.

The entire field should not be seeded at one time. Preferably, successive sowings should be made at intervals of 10 to 14 days throughout the lettuce planting season. This extends the marketing of the crop over a longer period and gives a more uniform distribution of labor in both packing house and field throughout the season.

THINNING AND HOEING

Lettuce should be thinned before the plants start to crowd. In warm weather this may be three weeks after planting, but in cool weather it may be delayed as long as eight weeks. The plants are blocked out 12 to 15 inches apart in the row by special short handled hoes and at the same time thinned by hand to one in a place. Plants not true to type should be removed at this time. It is best to give the plants plenty of room in the row.

Thinning is a very important operation, and in many cases when it is done under contract, a part of the money is withheld until the job is finished in a satisfactory manner. Beds and furrows are usually cultivated before thinning. It is usually stipulated that all weeds left by the cultivator be removed by those doing the thinning, that the plants stand at a specified distance in the row, and that no doubles be allowed to remain. When there is danger of damage by insects, thinning should be delayed until the pests have been destroyed.

After thinning it is necessary to hoe to kill the weeds, remove doubles, and re-thin where it is needed. In hoeing, the soil should not be pulled up to the plants, as this obstructs free circulation of air and facilitates the development of diseases.

IRRIGATION AT PLANTING TIME

The system of irrigation used at time of planting varies with the locality and with the climatic and soil conditions. (1) In some regions the land is flood irrigated, the beds are made, and the seed is planted and no further irrigation is given until the seedlings are through the



Fig. 18.—Irrigating lettuce beds. Water enters the furrows from the head ditch through small conduits. Usually only one is used for each furrow. The pieces of shook beside the opening is used to regulate the flow. Imperial Valley.

soil. This system can be practiced where the soil dries out slowly. (2) Where evaporation is very high, in addition to the preliminary flood irrigation, it is the practice to irrigate immediately after planting. Beds made of moist soil settle more evenly after irrigation than when made of loose, dry soil. (3) Rough beds are sometimes made in land that has not received a preliminary flooding. The beds are wet by running water in the furrows, as shown in figure 18. This irrigation moistens and settles the beds which when sufficiently dry are smoothed and planted. (4) Seed is sometimes planted in dry soil that is irrigated only after the seed is planted. This is probably the least satisfactory method of all, as the beds usually settle unevenly at the first irrigation and during subsequent irrigations there is danger of flooding.

When furrow irrigating, the water should be allowed to sub through the beds and, if given time, it will finally moisten the entire bed. Irrigating the beds immediately after planting, as shown in figure 19, is usually preferred in warm dry weather. The water is often kept running in small streams down the furrows until the plants are up. This cools the soil and produces a higher percentage of germination. In cool weather such heavy irrigation immediately after planting is not necessary. In heavy clay soils, deep furrows are used with a small head of water. If the water comes up close to the top of the bed, the soil will bake and crack when it dries and the seedlings will not come through.



Fig. 19.—The seed has been planted and the beds are being irrigated. Irrigation immediately after planting is an important operation in most of the lettuce producing areas of California.

Regardless of location, however, the soil about the seed and above it should be kept moist until the seeds have germinated and the seedlings are through the soil. More care must be exercised in getting the plants up in the hot arid regions than along the coast, where the sea breezes and cool temperatures prevent rapid evaporation. The time and method of irrigation depend largely upon the climatic and soil conditions.

IRRIGATING THE GROWING CROP

The details of irrigation practice vary considerably in different localities and at different times of the year. It is best to irrigate very sparingly when the plants are small, as this will make the lettuce

develop a deep instead of a shallow root system. If too much water is applied when the heads are maturing, they are liable to be soft and loose. Heavy rains just before cutting time often cause the development of open spongy heads. Small plants need much less water than larger ones. Less water is required when the weather is cool, and humid, than when hot, dry, and windy. The frequency of irrigation of lettuce also depends on the water-holding capacity of the soil and the slope of the land. More frequent irrigations are needed on light sandy soils than on the sandy or clay-loam soils which are more retentive of moisture.



Fig. 20.—Irrigation and drainage ditches. The drainage ditch at the right is carrying off the water after it has passed down between the beds. The irrigation ditch at the left is ready to receive water and conduct it to the furrows between the beds. A more uniform control of moisture conditions can be obtained if the rows are not too long. Cross ditches for irrigation and drainage facilitates the equable distribution of water.

While it takes some experience to tell just when lettuce needs water, in general, the plants are suffering for lack of water when they take on a dark green color and the leaves look and feel tough and leathery. When the moisture supply is plentiful, the leaves are crisp and have a light green color. During frosty weather, growers commonly practice night irrigation to raise the temperature of the air around the lettuce.

Devices for Regulating Water Flow.—Most of the growers use a series of small wooden conduits or flumes to carry a small stream of water from the end ditch to the furrows between the beds. A conduit is made of four laths or slightly wider strips 20 to 24 inches long, nailed together. It should be sufficiently long to fit well in the ditch

bank. Pieces of shook or lath can be placed in front of the conduits to regulate the flow. Galvanized or iron pipes cut to the same length as the wooden conduits are often used. Iron pipes are more permanent and sizes from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in diameter are generally used.

CULTIVATION

Irrigation should never take the place of cultivation. A mistake often made by inexperienced growers is to apply water when a good cultivation is needed instead. Too frequent irrigations keep the soil



Fig. 21.—Cultivating lettuce. The cultivator on the right works the top and sides of the bed and precedes the cultivator on the left, which stirs the soil in the furrows.

wet and cold, while cultivation helps to warm it by facilitating aeration. The soil should be cultivated after each irrigation and before a hard crust has formed. As the lettuce plant is a shallow feeder and a rather poor forager, care must be taken not to injure the root system by deep cultivation, especially during the later stages of growth. A majority of the growers stop cultivating at least a week or ten days before harvesting commences, in order not to disturb the extensive system of feeder roots growing close to the surface of the ground. The most common practice is to cultivate the furrows and sides of the bed with a one-horse cultivator as soon after irrigating as possible. This operation partially fills the furrows, which makes it necessary to open them up before the next irrigation.

In some districts an implement like the one shown in figure 21 is used to cultivate the soil between the rows of lettuce on the bed and in the furrows at the same time. Regular beet cultivators and small wheel hoes are frequently used to cultivate the beds. Care must be taken not to cover the plants or to pull dirt away from the edge of the beds and expose the root systems. (See fig. 22).

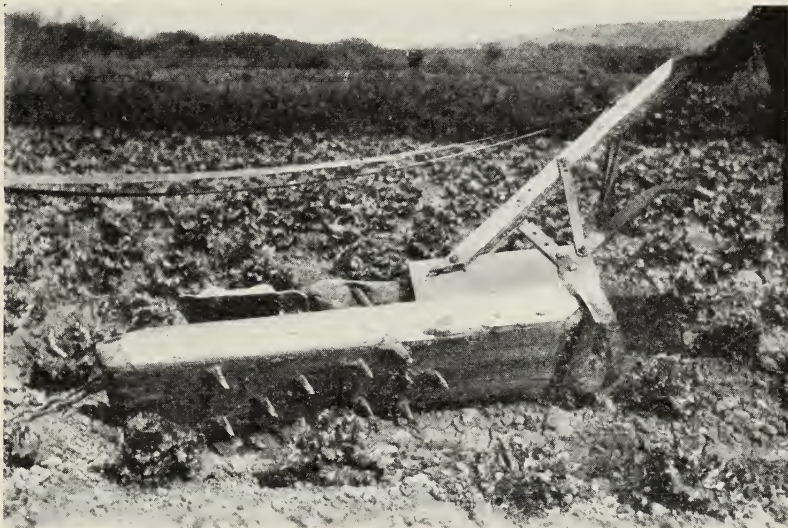


Fig. 22.—A lettuce cultivator in use in the Pajaro Valley. A plank is rounded to fit in the furrows. There are nine harrow teeth and an adjustable knife in the rear. This type of cultivator does not throw dirt on the lettuce plant.

YIELD

The yield varies considerably from year to year. Over a five-year period, from 1919 to 1923, the average number of crates to the acre for California was 249, 258, 335, 208 and 222, respectively. This gives some indication of the number of crates that may be expected.

HARVESTING

(1) Harvesting should not be done until the heads are “mature” (firm). Immature heads wilt more readily. In cutting lettuce immature, the grower ruins the market for the high grade product. When ready to be cut, the tops of the mature heads are lighter colored than those of the immature, and have a silvery appearance.

(2) Lettuce should be cut just below the surface of the ground, as shown in figure 23. The most of the trimming of the outer leaves should be done at the packing shed.

(3) Lettuce is usually cut by contract labor. A gang of cutters go down the rows cutting the matured heads and tossing them into every third furrow with stems up so as to allow the moisture in the head to drain out. A second gang of men then pack the heads tightly, with stems up, into crates as indicated in figure 24, and load them on wagons. The crates are then hauled to the packing shed.



Fig. 23.—Harvesting lettuce, showing the type of knife used and the method of cutting off the root just below the ground.

(4) Lettuce should not be cut for shipment immediately after a rain or an irrigation, or until the frost and dew is gone in the morning. When the plants are gorged with water, the leaves are crisp and brittle and break easily in handling. Lettuce heads that are just slightly wilted are injured less in handling and packing, and carry better in transit. Lettuce should not be cut when the field is muddy.

(5) Lettuce heads that show signs of development of seed stalk, that have burst, have tip burn, or show signs of disease infection should be discarded in the field.

(6) Growers should not attempt to harvest all the heads in the field at one cutting. Several cuttings must be made to obtain all heads at the best stage of maturity.

(7) Lettuce should not be delivered to the packing shed in a badly wilted condition. When the haul to the packing shed is long, the

crates should be covered with heavy muslin or canvas. The crates in the field should not be filled too full, otherwise there is danger of crushing or bruising by pressure from crates stacked on top. Figure 25 shows the usual method of hauling the crates of lettuce from the field, they are then transferred to large auto trucks, similar to those shown in figure 26, and hauled to the packing shed.



Fig. 24.—Placing lettuce in crates for delivery to the packing shed. Heads are cut and thrown into alternate furrows. They are then gathered into small piles and packed tight into crates for the trip to the packing shed. The crates should not be packed too full.



Fig. 25.—Hauling lettuce from the field.

(8) There is at times a tendency to harvest the lettuce before it has matured, especially if the price is high. Small heads of poor quality invariably bring a low price on the market. Most growers now realize that money is lost by premature harvesting. Mature lettuce can remain in the field for a long time without bursting when the weather is cool. In very warm weather or when freezes are expected, lettuce should be harvested as soon as it is mature.



Fig. 26.—If long hauls are made the crates are transferred to large auto trucks at the edge of the field. If exposed to the sun for a considerable period especially during warm weather the load is usually covered with a canvas.

PACKING FOR SHIPMENT

At the packing shed, the loose, diseased, and damaged leaves are trimmed off, as shown in figure 27, and the small or loose heads culled out. Too many wrapper leaves should not be removed as this increases the danger of bruising. When trimmed, the heads are tossed on to the packing table, where they are placed in crates, as shown in figure 28. They are usually packed in the "Los Angeles" crate, which is 24½-in. by 18-in. by 13-in., or in the "Imperial Valley" crate, which has the same outside dimensions, but is longer inside. From 2½ to 7 dozen are put in each crate, according to the size of the heads.

The lettuce crate is lined with two strips of heavy water-proofed paper, which cover the bottom, sides, and ends and fold over the top to protect the contents from dirt and infection, to keep the lettuce

cool and fresh, and to prevent mechanical injuries to the heads. Three layers of heads are packed tight in the crate with stems up, generally with cracked ice between the layers, as shown in figure 29. Usually not over 30 pounds of ice is used in each crate. The crates should be placed in the refrigerator car as soon as packed. From 4500 to 7500



Fig. 27.—Trimming lettuce. The butts and damaged or diseased leaves are trimmed off. The waste leaves are used for poultry, cattle or hog feed.

pounds of ice, according to the weather, is placed in the car, usually on top of the crates in the car instead of in the bunkers. A slight bulge, as shown in figure 30, is given the crate so that the heads will not move about in the container. The usual carload is 320 standard crates, which are stacked 5 wide, 4 high, and 16 long, each stack being securely "stripped" together and braced well between the two halves of the car to prevent sliding and moving.

GRADING AND STANDARDIZATION

The permanent success of the California lettuce industry can be assured only by placing upon the market a product of high quality, that is rigidly graded and highly standardized.



Fig. 28.—Packing and trimming in the packing shed. In the background the men are cutting back the stems, and removing the diseased and damaged leaves. The trimmed heads are then tossed on to a low table in reach of the packers.



Fig. 29.—Cracked ice is placed between the layers of lettuce when packed. From 25 to 30 pounds of ice are used in each crate. This cools the lettuce and tends to insure its reaching the eastern markets in good condition.

Californian shippers are not required to use any specified grades but the value of rigid grading is so apparent that most of the shippers have voluntarily adopted the Federal Grades.

U. S. GRADES FOR LETTUCE

U. S. Fancy	U. S. No. 1	U. S. No. 2
Shall consist of <i>Heads of Lettuce</i> <i>WHICH ARE</i> of similar varietal characteristics fresh well trimmed SOLID <i>WHICH ARE NOT</i> decayed split burst <i>WHICH ARE FREE</i> <i>FROM</i> seed stems DOUBLES FREEZING DAMAGE damage caused by dirt damage caused by wilting tip burn damage disease damage insect damage mechanical damage damage by other means	Shall consist of <i>Heads of Lettuce</i> <i>WHICH ARE</i> of similar varietal characteristics fresh well trimmed OF REASONABLE SOLIDITY <i>WHICH ARE NOT</i> decayed split burst <i>WHICH ARE FREE</i> <i>FROM</i> seed stems DOUBLES FREEZING DAMAGE damage caused by dirt damage caused by wilting tip burn damage disease damage insect damage mechanical damage damage by other means	Shall consist of <i>Heads of Lettuce</i> <i>WHICH ARE</i> of similar varietal characteristics fresh <i>WHICH ARE NOT</i> decayed burst <i>WHICH ARE FREE</i> <i>FROM</i> seed stems SERIOUS FREEZING DAMAGE wilting damage caused by tip burn damage disease damage insect damage mechanical damage damage by other means

In order to allow for variations incident to proper grading and handling, not more than 10 per cent, by count, of any lot may be below the requirements of these grades.

DEFINITION OF TERMS

As used in these grades:

“Similar varietal characteristics” means that the heads in any container have the same color and characteristic leaf growth. For example, lettuce of the Iceberg and Big Boston types must not be mixed.

“Fresh” means crisp and green.

“Well trimmed” means that the coarse and damaged outer leaves have been removed, leaving the head protected by green wrapper leaves. Heads which show a considerable number of wrapper leaves in excess of those required to protect the head shall not be regarded as well trimmed. Heads showing a ragged appearance caused by the removal of portions of the outside leaves shall not be considered U. S. No. 1.

“Seed stems” means those heads which have seed stems showing or in which the formation of seed stems has plainly begun.

“Solid” shall be interpreted as “hard” for Iceberg type and “firm” for the Big Boston type.

“Of reasonable solidity” shall be interpreted as “firm” for Iceberg type and “fairly firm” for Big Boston type.

“Fairly firm” means that the head is well formed and not soft or spongy.

“Free from damage” means that the heads shall not be injured to an extent readily apparent upon examination.

“Free from serious damage” means free from any injury which causes a loss of a portion of the edible part of the head. The loss of the crispness due to freezing shall not be considered serious damage.

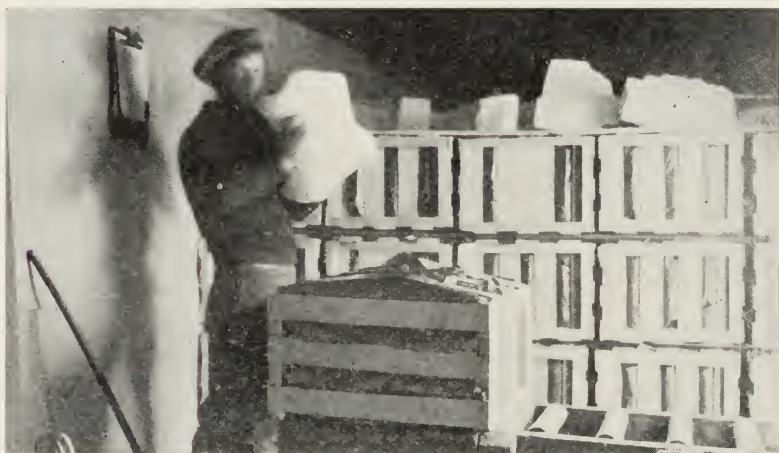


Fig. 30.—Loading car with lettuce. Crates are stacked 4 deep, 5 wide, and 16 long, and are held firm by wooden strips. Ice is placed on top of the upper tier of crates. Figure also shows a packed crate with the desirable bulge.

INSPECTION*

“In July, 1920, there was established in California a commercial shipping-point inspection service carried on by the Bureau of Standardization of the State Department of Agriculture. This service employs a corps of experienced, highly trained men who are authorized to inspect and certify to the exact quality and condition of the produce at time of packing and shipping. The demand for this service has increased steadily and its scope and importance has been greatly

* Successful marketing of the California Vegetables. Special Publication No. 32, California State Department of Agriculture.

enlarged. * * * On July 1, 1922, this service was federalized, each inspector being deputized by the federal government, and certificates issued are now *prima facie* evidence in all courts of the United States."

"This inspection is available in all of the leading vegetable producing sections of the state. The certificate shows the hour and date of inspection, inspection or shipping point, name and address of the shipper and consignee (when given), car initials and number, kind of car and its condition; if a refrigerator, the amount of ice in the bunkers; the quantity of the products inspected; description of load and container; condition of pack; sizing, quality and condition of the products; color, grade remarks. The buyer, therefore, knows the exact quality and condition of the product at the time the car is loaded, although he may be at a considerable distance from the shipping point. These shipping-point certificates are valuable to the grower, as they protect his interests in the adjustment of claims or on a declining market. On the other hand, the buyer is assured that he will receive the quality of produce for which he has paid before seeing it. Whenever requested, a telegram giving the substance of an inspection will be sent "collect" to the buyer or any other interested party, so that the exact condition of a carload can be ascertained before the sale is even consummated."

INSECT PESTS AND THEIR CONTROL

Cutworms.—Probably the most common serious pest that the growers of lettuce have to contend with is the cutworm. The most damage is done while the plants are small, the young plants usually being cut off at the ground level. The best protection obtained has been by using poisoned bait. The following formula is recommended:

Paris Green (or white arsenic).....	1 pound
Molasses (cheap black strap).....	2 quarts
Water	4 gallons
Wheat bran	25 pounds

The addition of $\frac{3}{4}$ of an ounce of amyl acetate of the technical No. 1 grade to this formula has been found advantageous in the Imperial Valley. In preparing the mash, the amounts should be measured carefully. The white arsenic or Paris Green should be thoroughly stirred with the molasses and water. This poisoned mixture should be poured over the bran and stirred thoroughly. Enough water should be added to make a crumbly, but not a wet mash. When squeezed in the hand, only two or three drops should come out. This mash should be spread on top of the beds near the plants in the early evening, as cutworms do most of their damage at night. Dusting or spraying the

plants with arsenate of lead is useful when the plants are young, but should never be practiced when the crop is approaching maturity.

A severe infestation of cutworms, alfalfa semi-loopers, and caterpillars of the yellow alfalfa butterfly occurred in the Imperial Valley in 1923. The growers at that time were able to bring their fields through in good condition by observing certain recommended practices. If the lettuce pests mentioned above are present in large numbers, the field should be dusted or sprayed with lead arsenate before thinning. If the attack is especially severe, arsenate of lead should be dusted on undiluted. If the pests are not especially abundant, satisfactory results can be obtained by using a mixture containing one part of arsenate of lead and four parts of powdered air-slacked lime, finely ground gypsum, sulfur, or cheap flour. Dusting is probably better than spraying.

Grasshoppers.—Grasshoppers sometimes devour entire fields of young fall planted lettuce. It should be the regular practice of all growers to burn the grass and weeds, and to work the ground along the roads and ditch banks adjoining their fields, as the female grasshoppers lay their eggs in the surface of the soil of these untilled areas. As much trouble may be expected from grasshoppers where lettuce fields adjoin alfalfa or pasture lands, some arrangement should be made, if possible, to have these fields thoroughly disked or harrowed. When alfalfa land is being broken up for lettuce, it should be disked or harrowed before plowing in order to destroy the eggs of grasshoppers and other insects and the pupal stages of cutworms.

When grasshoppers appear in the field, a heavy irrigation should be given to moisten the ground thoroughly. The best way to fight grasshoppers is to use the poison bran mash recommended for cutworms with the addition of $1\frac{1}{2}$ dozen chopped lemons and 1 pound of salt. The substitution of $\frac{1}{2}$ -pound of sodium arsenite for the Paris Green is also recommended. This mash should be spread in the early morning, as grasshoppers do most of their feeding during the day.

BIRDS

Hundreds of acres of young lettuce are sometimes devoured by English sparrows in some sections of the state. Probably the best method of controlling these pests is to erect a large number of small scarecrows throughout the field in the form of bright pieces of cloth or paper fastened to laths or sticks, and in addition to use a shotgun for a day or two. Good results will be obtained by using small kernelled, or cracked wheat, lettuce seed, or "bird seed" coated with strychnine. Good results have been obtained also by use of a formula

recommended by the United States Department of Agriculture. To one-eighth ounce of pulverized strychnine dissolved in three-fourths of a gill of hot water, one and a half teaspoonfuls of starch or wheat flour moistened with a few drops of cold water are added. This mixture is heated while constantly stirring until it thickens. It is then poured over one quart of wheat and stirred until every kernel is coated. This should be distributed over the areas in the field where the birds are feeding.

DISEASES

Tip-burn.—Tip-burn is a non-parasitic disease and is most likely to be prevalent during the summer, especially when warm bright days follow a period of foggy or cloudy weather. In a preliminary report, Rawlins and McClain* state that “the first evidence of the trouble is usually the development of small brown spots near the edge of the upper, more tender exposed leaves. These spots usually develop first at the junction of small veins about one-quarter to one-half inch from the edge of the leaf. The development of these small dead spots seems to prevent the passage of water to the edges of the leaf and that portion outside of the spots becomes wilted and yellow and soon dies, leaving a dead, brown strip around the edge of the leaf. The only practical way in which the farmer may hope to evade tip-burn during the warmer months is through the use of resistant varieties. The most promising variety showing resistant qualities is Iceberg.”

Slimy Soft Rot or Slime.—Slime is a disease caused chiefly by the fungus *Botrytis*, although a number of bacteria have been found associated with it. The disease appears in the field, in transit, and in storage, and is characterized by a slimy and slippery condition of the affected parts and by a very offensive odor. Tissues of lettuce are predisposed to slime by the bruising of the leaves during handling, by frost injury, by tip-burn, and sun-scald. In the field the control of slime usually resolves itself into the control of tip-burn. In transit, it can be kept in check by packing only healthy and uninjured heads and by shipping under dry, cool conditions. It is impossible to keep the heads dry, however, with our present methods of handling.

Downy Mildew.—Downy mildew is caused by the fungus *Bremia lactucae*. The first indications of the disease appear a slight green or yellowish areas on the upper surface of the leaf. On the under side of these discolored areas there soon appears a downy white growth of mold. The older diseased areas take on a brown color. Milbrath†

* Tip-burn and slime disease of lettuce. Pacific Rural Press, March 14, 1925.

† Downy mildew on lettuce in California. Journal of Agricultural Research, 23:989-993. 1923.

states that "an increasing amount of downy mildew has developed particularly since the variety New York is susceptible to that disease. In the Imperial Valley the disease was found in a milder form than in other districts. In the Los Angeles district, the fungus was found on lettuce during all months of the year, but appeared to be most active from October to May. During this period, in many fields where the plants were approaching condition for harvest, 90 per cent of the crop was affected severely, that is to say, the fungus was found on most of the exposed leaves regardless of age. In a survey of the whole district during the season of 1919-20, an estimate of 40 per cent severe infection was made. In the Watsonville and Sacramento

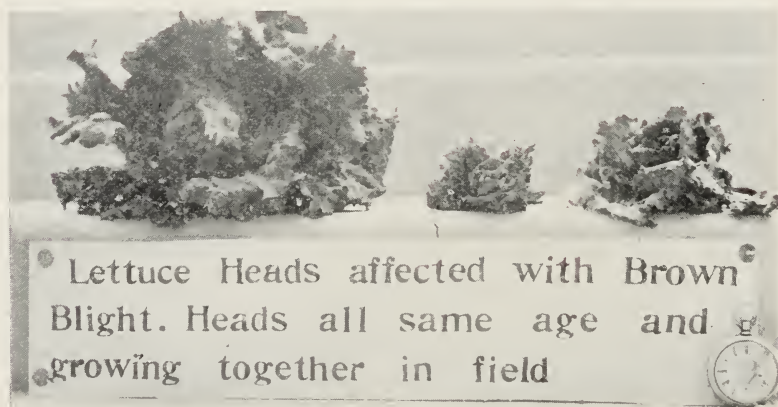


Fig. 31.—Plant on left normal, others are affected with Brown Blight.

districts the severity of the disease was similar to that in the Los Angeles district." Downy mildew has also been reported in the Colma district.

This disease is important because it attacks the edible leaves of the plant and in transit predisposes the plant tissue to slimy soft rot. So far no methods have been developed for its control.

Brown Blight.—Dr. I. C. Jagger, Plant Pathologist of the United States Department of Agriculture, reports that the Brown Blight disease has caused noticeable injury to the lettuce crop in Imperial Valley. It has also been found recently in other parts of the state and in Arizona.

Plants are attacked by the disease from the time they have five or six leaves until their heads are fully matured. Small plants, when attacked, become yellowish in color, stop growing, and fail to head. Such plants produce a few small, yellowish, new leaves, which lie flat on the ground. This stunts the entire plant, as shown in figure 31. Headed or partly headed plants on becoming diseased usually show

dark-brown, dead, irregular blotches and streaks in the leaves. Beginning with the bottom leaves, the affected plants turn brown and wither.

There may be a few diseased plants scattered throughout the field, or there may be smaller spaces in which all or a large percentage of the plants are diseased. The occurrence of the disease in localized areas is often noticeable, and has frequently led to the erroneous conclusion that it is associated with alkali "spots." In severe cases, entire fields may have from 50 to 90 per cent of the plants affected.



Fig. 32.—Field of lettuce on the right shows from 75 to 100 per cent Brown Blight infection. Lettuce was grown on this field the two preceding years. The field on the left shows from 20 to 40 per cent Brown Blight infection. This field produced a lettuce crop the preceding year. Imperial Valley.

In the Imperial Valley the disease occurs in nearly all fields, but in general it causes appreciable injury to the crop only where lettuce is grown on the same land for two or more years. (See figure 32). Fields growing lettuce for the first time often have from 2 to 5 per cent of the plants infected. A succeeding crop may have as high as 50 per cent of the plant diseases, while the third year the crop may be practically a total failure. Where a field has only a very few diseased plants, a good crop of lettuce can usually be grown on the same land the following year, but where as high as 2 to 5 per cent of diseased plants are present, it is probable that lettuce on this land the following year will have from 15 to 50 per cent diseased.

According to Jagger, the disease is caused by a parasitic organism, which lives in the soil. So far as known, only lettuce is susceptible.

Information on the effect of growing other crops like alfalfa and cotton for a few years on infested soil is limited, but in general, from one to three years of such crops have not sufficiently renovated the soil to make the growing of lettuce again profitable.

Some varieties are entirely immune to Brown Blight, but these are apparently worthless for growing in California. Very satisfactory progress is being made, however, in developing a strain of the New York variety which is immune or highly resistant to the disease, and which can be grown on infested land. Mr. Jagger expects that this resistant strain will be perfected and available for general use in a few years. Meanwhile, the only way of avoiding losses is to grow lettuce, so far as possible, in fields which are reasonably free from infestation.

SHOOTING TO SEED PREMATURELY

There has been much loss during the past three or more years due to lettuce plants going to seed prematurely. This may in some instance be due to poor strains, but it is usually caused by unfavorable soil, moisture, and climatic conditions. It is difficult to determine in all cases just what the contributing factor or factors have been in bringing about this condition. Probably one of the most general causes is insufficient irrigation during periods of high temperature or when dessicating winds are prevalent. Growers who do not permit the growth of the plants to become checked during periods of adverse climatic conditions are going a long way in preventing the fields from going to seed prematurely. The best lettuce seed available should be purchased. Buying cheap seed is not economy. Above all, growers should not attempt to grow lettuce under high temperature conditions, on steep slopes, or on light sandy or gravelly soils that are not retentive of moisture.

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